Design Manual for Roads and Bridges

Highway Structures & Bridges
Design

CD 351
The design and appearance of highway structures

(formerly BA 41/98)

Revision 0

Summary
This document provides requirements and guidance which aim to improve the aesthetic outcomes of schemes that include bridges and other highway structures.

Application by Overseeing Organisations
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
0	Mar 2020	CD 351 replaces BA 41/98. This document introduces the aesthetic appraisal document, which helps demonstrate how aesthetic quality has been taken into account in the design of highway structures. This full document has been re-written to make it compliant with the new Highways England drafting rules.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes BA 41/98, which is withdrawn.

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

Background

This document provides requirements and guidance which aim to improve the aesthetic outcomes of schemes that include bridges and other highway structures. It outlines an underlying approach to encourage best practice, establish intended outcomes that support aesthetic quality, and evidence how these can be addressed throughout all stages of the design life-cycle of a highway structure.

The provisions in this document are not instructions for how to design good highway structures, but are prompts for all parties involved throughout the design life-cycle to improve aesthetic quality and design outcomes.

This document is intended for use by engineers, architects and planning professionals, as well as to inform communities of the design philosophy and principles that can be implemented to ensure good design.

Aesthetics is only one of the aspects affecting good road design, and has to be balanced with functional and technological considerations covered in other DMRB documents as relevant.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 2.N] apply to this document.

Abbreviations

Abbreviations

Abbreviation	Definition
AAD	Aesthetic Appraisal Document
AC	Aesthetic Category
AIP	Approval in Principle
GRP	Glass Reinforced Plastic

Terms and definitions

Terms

Term	Definition
Design life-cycle	The period of time between the inception of design and the point at which the designed item no longer exists in its designed form. NOTE: Design life-cycle includes the stages of option identification, option selection, preliminary design and detailed design and is to include any design changes that occur during the construction and commissioning period.
Discipline	A branch of knowledge involved in the design of highway structures, for example highways, drainage, structural engineering or architecture.
Highway structure	Structure or installation as defined in accordance with CG 300 [Ref 4.N].
Project review panel	A body which includes representation from the stakeholders in the project (e.g. from the Overseeing Organisation or users of the project deliverables), which helps ensure that the principles of good road design have been taken into account for an individual road scheme / project or a specific programme.
Recreational waterway	A waterway that typically sees high level of usage from members of the public, for recreational purposes such as boating, sailing, swimming etc.

1. Scope

Aspects covered

1.1 This document shall be followed to demonstrate how the aesthetic quality has been taken into account throughout the design life-cycle of all categories of highway structures for new construction and renewal schemes.

NOTE 1 This document does not provide prescriptive rules or a formulaic approach on how the subject of aesthetics is dealt with for highway structures; instead, it covers:

1) overarching aesthetic influences relevant to highway structures;

2) the process of identifying, evidencing and working towards positive aesthetic outcomes.

NOTE 2 Aesthetic impact is not limited to higher profile, landmark structures that stand out as a result of their scale, location or role within their local cultural vernacular, but also to structures that are regarded as commonplace, widespread and therefore highly visible elements within the highway network.

NOTE 3 The objectives and processes set out in this document are based on general principles of design excellence and complement the principles of good road design established within GG 103 [Ref 1.N].

Implementation

1.2 This document shall be implemented forthwith on all schemes involving the design and appearance of highway structures on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 2.N].

Use of GG 101

1.3 The requirements contained in GG 101 [Ref 2.N] shall be followed in respect of activities covered by this document.

2. Approach to design

2.1 The design process of highway structures shall include an evaluation of all aspects that affect the aesthetic quality of the completed structure, its position in the landscape and its impact on social, cultural and heritage sensitivities within the community.

NOTE 1 The treatment of aesthetics is a fundamental component of the design process throughout the design life-cycle from its outset.

NOTE 2 Appendix A provides guidance on aesthetic aspects that can influence the design process.

NOTE 3 Appendix B provides guidance on the approach to design for highway structures in general.

NOTE 4 Appendix C provides guidance on the approach to design specifically for highway bridges.

NOTE 5 The NN NPS [Ref 4.I] sets out a number of assessment criteria which affects the quality of design for a highway structure.

2.2 The design input across all disciplines involved in the design process of structures within a highway environment shall be coordinated to achieve outcomes of aesthetic merit.

2.3 Liaison shall be maintained with the relevant Overseeing Organisation throughout design development and any statutory consent procedures.

3. Aesthetic appraisal document

Development and approval

3.1 The aesthetic appraisal document (AAD) shall be reviewed and updated at key stages throughout the design life-cycle and submitted for approval to the Overseeing Organisation at agreed milestones.

NOTE *The AAD is the means by which the key influences and decisions that shape the approach to aesthetics is recorded and agreed.*

Content and scope of application

3.2 The AAD shall be a live document, updated at key stages throughout the design life-cycle.

3.2.1 The AAD should communicate a clear design narrative that demonstrates an appreciation of the aspects identified in Table 3.2.1 throughout the various stages of the design life-cycle and provide a clear description of the rationale underpinning all key decisions that influence the aesthetics of structures.

Table 3.2.1 : Core information for inclusion in the AAD at the different stages of the design life-cycle

Design life-cycle stage	AAD information
AAD 1(1) - Project initiation (prior to option finalisation)	1) the structure's location, function and any site specific constraints or sensitivities identified; 2) any specific requirement to take architectural advice; 3) aesthetic category (2); 4) project review panel make up, where relevant (3)

Table 3.2.1 : Core information for inclusion in the AAD at the different stages of the design life-cycle (continued)

Design life-cycle stage	AAD information
AAD 2.1 - Preliminary design AAD 2.2 - Detailed design (5)	Design outcome objectives (4) Aspects related to context including: 1) key transportation and functional requirements and physical features to be negotiated; 2) key physical, cultural and social connections to be established and maintained; 3) user mode interfaces and accessibility constraints; 4) challenges and opportunities associated with local community/cultural imperatives and heritage aspects; 5) significant environmental issues, challenges and opportunities; 6) key relevant aspects of context of the structure that are to be accommodated within the design; 7) potential structural forms and proportions to suit geometric and loading constraints; 8) identification of context-specific materials or finishes, where relevant. Aspects related to the process including: 1) milestones at which the AAD is updated throughout the design process (at preliminary and detailed design as a minimum); 2) lead discipline and all other contributing disciplines that are anticipated to be involved in the design process of the highway structures; 3) extent and process for public/stakeholder consultation. Aspects related to specific project requirements including: 1) vehicle containment/parapet requirements; 2) signage and lighting requirements.
AAD 3 - Construction	Changes to design as a result of site constraints or construction process requirements (as necessary)
AAD 4 - Post construction review	Feedback on how well the final design and completed structure have met the design outcome objectives (4)
Note (1): AAD1 is the outline AAD which is typically prepared by the Overseeing Organisation which forms part of the project brief. Note (2): See "Aesthetic category" in Section 3. Note (3): The size and make-up of the project review panel, which is set up by the Overseeing Organisation where needed, is appropriate to the aesthetic category and scale of the project. For smaller scale projects, a project review panel can comprise a single, named responsible person. Note (4): See "Design outcome objectives" in Section 3. Note (5): AAD 2.1 is intended to provide considerations affecting the aesthetics of the whole structure, whereas AAD 2.2 is intended to provide considerations affecting both the whole structure and specific parts.	

3.2.2 The AAD should be as concise as possible whilst providing clarity and continuity across the design

life-cycle.

NOTE *The level of supporting detail and extent of content within the AAD increases from category AC1 to category AC3 (see "Aesthetics category" in Section 3).*

3.2.3 An AAD may be produced for individual structures or alternatively for a family of structures on a scheme, where relevant.

3.2.4 Where aspects are covered within documents already required by other standards/processes, a reference to the relevant, alternative source may be included in lieu of a detailed description.

NOTE *The AAD can be used to inform other formal procedures including technical approval, planning, consents and environmental assessments.*

3.3 Any amendments required as a result of the outcome of the consent process shall be recorded within the AAD.

Aesthetic category

3.4 The level of detail and extent of content within the AAD shall be commensurate to the aesthetic category (AC) of the structure.

NOTE 1 *The aesthetic category of the structure is based on the underlying characteristics identified in Table 3.4N1 for AC1, AC2, AC3.*

Table 3.4N1 Aesthetic category characteristics

Category	Characteristics
AC3	1) landmark structures that can generate significant local or national interest; 2) structures that have a significant visual effect (1) in locations with environmental, heritage, landscape and visual sensitivities. For example structures in sensitive areas as defined in LA 102 [Ref 3.N].
AC2	Structures that could be regarded as relatively widespread but are highly visible elements in themselves, within the highway network, which can include: 1) structures that form grade separated junctions; 2) structures in densely populated areas or that are adjacent to or cross roads that carry significant volumes of traffic; 3) structures that are adjacent to or cross recreational waterways; 4) structures that are adjacent to or cross routes used by walkers, horse riders and cyclists, and shared used paths; 5) bridges that provide access to recreational areas/parks.
AC1	All others.
Note (1): Guidance and requirements on assessing the significance of visual effects is provided in LA 107 [Ref 2.I].	

NOTE 2 *The initial aesthetic category of the structure in AAD1 is defined by the relevant Overseeing Organisation.*

NOTE 3 *The aesthetic category is not the same as the structure category for technical approval, see CG 300 [Ref 4.N].*

3.5 Any change to the initial aesthetic category from AAD1 shall be agreed with the relevant Overseeing Organisation.

3.6 An evidence base appropriate to the aesthetic category allocated shall be developed through the aesthetic evaluation process during the various design life-cycle stages.

Design outcome objectives

3.7 The design outcome objectives shall be defined no later than the AAD2 stage.

3.7.1 The design process should not start with any preconceptions about the aesthetics of the final solution.

NOTE *Different structure types have their own particular characteristics in terms of materials, components etc.*

3.7.2 The key objectives for the design outcome should be understood and defined through a multi-disciplinary design and review process, focusing on aspects such as:

1) proportion and integration of structure scale within the landscape;
2) options for contrast/harmony with surrounding environment;
3) proportions of spans/length and height;
4) symmetry/rhythm/line/order of principal elements;
5) materials and finishes;
6) parapets and other elements that contribute to rhythm;
7) lighting and signage;
8) managing the effects of water and weathering;
9) structure curtilage;
10) viewpoints from and to the structure;
11) potential for developing a family of structures along route.

4. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	Highways England. GG 103, 'Introduction and general requirements for sustainable development and design'
Ref 2.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 3.N	Highways England. LA 102, 'Screening projects for Environmental Impact Assessment'
Ref 4.N	Highways England. CG 300, 'Technical approval of highway structures'
Ref 5.N	Highways England. GG 142, 'Walking, cycling and horse-riding assessment and review'

5. Informative references

The following documents are informative references for this document and provide supporting information.

Ref 1.I	CIRIA. Soubry, MA. CIRIA C543, 'Bridge detailing guide'
Ref 2.I	Highways England. LA 107, 'Landscape and visual effects'
Ref 3.I	Highways England. LD 117, 'Landscape design'
Ref 4.I	NN NPS, 'National Networks National Policy Statement (NN NPS)'
Ref 5.I	The Concrete Society. CS 171, 'Visual concrete - planning and assessment'
Ref 6.I	Highways England. CD 361, 'Weathering steel for highway structures'

Appendix A. Aesthetics aspects that can influence the design process

The following values relating to both substance and process should be integral to the design approach in order to achieve structures of aesthetic merit:

1) commitment to aesthetics;
2) community/stakeholder engagement;
3) understanding of sensitivity of context;
4) balancing cost and aesthetics;
5) sustainability of outcomes;
6) rigour within the design process;
7) collaboration between all relevant disciplines.

A1 Commitment to aesthetics

All relevant parties should commit to achieving good aesthetics, including the client, the design team and the contractor during the design life-cycle.

A2 Community/stakeholder engagement

Early engagement and regular communication with local communities should form part of the design process.

Bridges in particular tend to be highly visible structures that are viewed not only by road users, but also by local community members. As such, they can impact visual amenity and sense of place. They can affect historic and cultural values or provide a sense of local identity.

A3 Understanding of sensitivity of context

The sensitivity to the way in which a structure sits within the landscape or built environment and its ecological and community context should be assessed.

It should be understood through all design stages that, whilst the structure itself is a unity, the site and the structure also represent a unity and therefore technical and aesthetic decisions should not be separated from each other. There should always be an interaction between them.

A clear understanding of the broader context within which the structure sits that can influence the designer's aesthetic response should be developed and documented. These may include:

1) topography;
2) function;
3) adjacent land use and infrastructure features;
4) the presence of other highway structures (either adjacent to or along route);
5) geotechnical and geological characteristics;
6) character of landscape or built environment;
7) ecology/biodiversity;
8) views of or in the case of bridges, from the structure;
9) community values and objectives.

A4 Cost and aesthetics

Cost and aesthetics should be balanced in order to develop an optimum solution.

Good design and aesthetics need not lead to an expensive outcome. Durability and build quality are often related and drive whole life costs in terms of maintenance and serviceable life.

A5 Sustainability

The sustainability of outcomes should be evaluated as they can directly influence the aesthetic outcome, insofar as they can be reflected by:

1) respect for heritage;
2) improved amenity for local communities;
3) connectivity of communities;
4) network resilience;
5) accommodation of inspection and maintenance;
6) longevity in terms of flexibility for future adaptation.

GG 103 [Ref 1.N] provides requirements and guidance for sustainable development and design.

A6 Coordination of disciplines within the design process

When the proposed solutions flow from an understanding of the fundamental design requirements, context and design outcome objectives, the rationale for selecting a single preferred concept becomes transparent.

It is particularly important that the highway design and structure design are well coordinated. The structure should properly relate to the road and decisions that can fix the alignment and the land-take requirements should not be made without the involvement of the structure designer.

The extent and shape of associated earthworks have a great effect on the structure design and on the general landscape context, and their inter-relationship should be coordinated between the highway designer, the structure designer and landscape architect. A predominant focus on earthworks and alignment aspects can have a detrimental impact on structure aesthetics.

A7 Collaboration between all relevant disciplines

A collaborative, multi-disciplinary approach should be adopted to explore a range of feasible design solutions and identify dependencies and wider opportunities. Collaboration between design professionals across the full range of necessary disciplines and engagement from the start of the design life-cycle should be facilitated to achieve a solution of aesthetic merit.

A highway structure is rarely designed by a single individual but will generally be the result of interactions between designers from multiple disciplines. This collaboration should begin at the earliest stage of design development in order to avoid outputs from one discipline becoming a constraint to others. These dynamic interactions are key to arriving at a balance and optimal solution. Conflicts that arise can be aired and resolved, resulting in a clearer path towards an optimal solution. For example, an open aspect structure, whilst potentially having a cost penalty relative to earthworks, can bring both aesthetic and environmental/ecological benefits and potentially reduce the costs of associated mitigation measures.

Input to the design team should ideally be provided by the client, structural and highway engineers, architect (where the aesthetic category merits this), landscape architect (where appropriate), with input from environmental, operation & maintenance and construction engineering specialists and others, as appropriate and identified in the AAD.

It is particularly important that the highway design and structure design are developed collaboratively between both disciplines. The structure should relate properly to the road and decisions which fix its alignment and associated land requirements should not be made without consulting the structure designer, particularly in the case of major structures such as bridges.

Appendix B. Approach to the design - general

B1 Scope of application

This appendix provides guidance for all highway structures on the approach to design incorporating an evaluation of all aspects that affect the aesthetic quality in general.

B2 Options development

It should be understood through all design stages that whilst a major highway structure such as a bridge in itself is a unity (i.e. in which structure, construction, materials, appearance and function are drawn together), the structure and its setting in the landscape are also a unity. Therefore technical and aesthetic decisions cannot be taken in isolation from each other. There will always be an interaction between them.

A highway structure will always become a component of its immediate environment. That environment will encompass many aspects, one of which is the immediate physical location (i.e. the site). The site will provide the most important influences with regard to what the appearance of the structure should be, or perhaps what it should not be. This will be a combination of technical, functional and aesthetic influences.

When approaching the design of any highway structure there will always be numerous options for solutions. The design process should therefore begin by developing a clear understanding of the full context within which the structure will sit, but keeping an open mind when developing options. Not all of these will be apparent at an early stage, and the most appropriate solutions may not become obvious until a good deal of effort has been expended.

Good design requires time and deep understanding of aesthetic, functional and technical considerations in order to fully understand and sensitively deal with potentially conflicting project requirements or constraints. Designers are normally expected to study alternative solutions undertaking preliminary analysis and cost estimates, to provide appropriate data to allow valid comparisons of solutions to be made. The first solution that comes to mind is rarely sufficiently developed to be considered as optimal; other options should be developed in parallel in order to identify the most appropriate solution that best satisfies the requirements of the client and users.

B3 The whole

A clear understanding of aspects of the broader context within which the structure sits that can influence the designer's aesthetic response should be developed and recorded. These can include:

1) topography;
2) function;
3) adjacent land use and infrastructure features;
4) the presence of other highway structures (either adjacent to or along the route);
5) geotechnical and geological characteristics;
6) character of landscape or built environment;
7) ecology/biodiversity;
8) views of or in the case of bridges, from the structure;
9) community values and objectives.

The design process should not start with any preconceptions about the final solution. The key objectives for the design outcome should be developed and defined through a multi-disciplinary review process, focusing on aspects such as:

1) integration of structure scale within the landscape;
2) proportions of spans and height;
3) symmetry/rhythm;

4) potential for developing a family of structures along a route.

Different structure types will have their own particular characteristics in terms of materials, components etc. The nature of use will significantly influence the structure type and form. For example, pedestrian/cycle bridges will be lighter and hence more flexible structures than highway or rail bridges.

In the case of highway structures, the shaping of abutting earthworks, whilst not part of the structure itself, should also be carefully considered. LD 117 [Ref 3.I] provides guidance on the interaction between bridges and landscape. Three dimensional graphics or simple physical models can be helpful in relating the embankment to the shape and scale of the structure within the landscape.

The structure itself should also be considered as a whole, not just an assemblage of parts. All elements should be related and all the parts be compatible with each other, serving the whole. For example, in the case of bridges, incompatibilities between approach viaducts (or ramps in the case of pedestrian structures) and the main structure should always be avoided through consideration of the whole.

Significant elements that have disparate angular arrangements within a structure can produce a disorganised effect, and truss type structures require particular care.

The form of the structure is what gives it its fundamental character. It is intimately connected with materials and the methods of construction as well as with safety and durability. Generally a structure should honestly and skilfully reflect the use of form and materials to achieve its aesthetic effect, by refinement of form and details.

Generally, forms and details that reflect the flow of internal forces are preferred to those which do not and therefore appear forced. For example, arches and suspension bridges reflect the flow of internal forces and are generally considered to be visually dramatic.This is equally as valid when designing contemporary structures as it was for historic ones.

B4 The parts

The form of the structure will encompass its external shape and overall appearance and how its individual elements are arranged and interrelate to one another in terms of scale and proportion. Structure specific guidance is given in Appendix C and D.

Appendix C. Approach to the design - bridges

C1 Scope of application

This appendix provides guidance specific to bridges on the approach to design incorporating an evaluation of all aspects that affect the aesthetic quality.

C2 The parts

The primary elements within a typical bridge can be grouped into:

1) superstructure;
2) substructure.

The following sections are not intended to be a comprehensive list of the parts to all types of bridge, but provide a brief commentary on the main elements that usually dominate aesthetic considerations. More detailed guidance may be found in the 1998 edition of BA 41 The Design and Appearance of Bridges.

C3 Superstructure

Superstructure elements can include:

1) above deck elements, for example pylons or arch ribs;
2) bridge deck;
3) parapets;
4) other deck furniture.

The bridge deck is usually the main visual organising element that links all other elements together and emphasises structural continuity.

C3.1 Bridge deck depth

By thoughtful shaping of the structure, the visual impact of the depth of the deck can be reduced (except in silhouette). These measures can help to lighten the appearance of the deck, which is usually positive but this may not necessarily always be the case.

Edge cantilevers overhanging the main structural elements can break up the visible depth of the deck, as the recession of the main structure and the shadow cast on it by the cantilever reduces the perceived overall depth.

C3.2 Bridge deck width

One of the challenges of modern highway bridges is that their decks can be very wide. Large areas of unbroken soffit tend to be visually dominant and potentially unpleasant, particularly where the soffit is relatively low and highly visible to users of the spaces beneath.

Edge cantilevers overhanging the main structural elements are usually, but not always, beneficial insofar as they reduce the visual impact of the width of the deck soffit, particularly where decks are set low within the landscape.

In the case of bridges carrying dual carriageways, the effects of large areas of unbroken soffit can be mitigated by accommodating the carriageways on separate decks with a gap between them that allows light to penetrate. Where this is not possible a main structure consisting of visibly separated beams or boxes may be favourable.

C3.3 Bridge deck length

Ideally the bridge deck should run throughout its length as cleanly as possible, i.e. sudden changes of depth or width should be avoided. If they are unavoidable, steps should be taken to minimise their effect, possibly by means of a strong dividing element as a transition.

An awkward effect is produced by an abrupt change of structure within a length of viaduct to accommodate a change in form, where structures of different sizes or types are juxtaposed without any transition element. If it is not possible to avoid an awkward junction at such a change in the structure, the two decks should be visually separated by another element.

C4 Substructure

Substructure elements can include:

1) piers;
2) pier head interface;
3) pilecap interface;
4) abutments.

C4.1 Piers

Generally, piers should be simple in form and where complex or elaborate solutions are adopted, the rational for departing from this approach should be recorded. If different forms of piers are adopted within the bridge they should be visually related to each other in some way.

C4.1.1 Pier form and placement

The form and placing of piers in relation to the deck should be carefully considered. Two examples of this are:

1) thin piers under a very thick deck can look discontinuous and visually awkward;
2) where the deck is of constant depth the piers can be inset from the edge in order to emphasise the visual flow of the deck and reduce the significance of the piers and their spacing.

C4.1.2 Pier shapes

Pier shapes should be carefully considered, not only in relation to each other but also in relation to the shape of the deck and how the two interact at their point of connection. There may also be situations where surrounding features dictate a specific visual response.

Piers with cross section that have a rectangular core with semi-circular ends tend to be less visually pleasing than those which have a cross section defined by a continuous curve, such as an ellipse.

C4.2 Abutments

Abutments provide a vital visual end stop to the bridge and create its transition into the landscape. Careful consideration is therefore needed in terms of how they frame the structure and interact with its form, rhythm and scale.

For rural bridges it is often preferable to have simple bank seats that are much less visually obtrusive and avoid the problems associated with large visible areas of concrete, but this may not always be possible.

From a road user's point of view, closed abutments provide more contained and focused views along the highway corridor, which can be an advantage in certain situations. The proportions of the opening then become particularly significant.

C5 The details

C5.1 Surfaces and weathering

An important factor in the appearance of surfaces is the way in which they weather.

All materials weather, including brick and stone, and can weather badly if not appropriately selected/specified or detailed. Careful consideration of the detailing between interfaces is necessary where combinations of different materials are used.

Concrete surfaces require the most attention, particularly large unrelieved concrete surfaces such as often found in large abutments or retaining walls, which are by their nature aesthetically challenging.

Edge cantilevers can help protect the main structure from the adverse effects of weathering.

C5.1.1 Effects of water flow

The majority of the undesirable visual consequences of weathering result from exposure to water through various mechanisms such as rain, condensation or spray created by moving vehicles, either through unevenly depositing dirt particles on a surface or by redistributing them through washing of the surface.

The designer should consider the way in which water will flow over the element surfaces and try to actively manage it as much as possible. In doing this it is necessary to think in three dimensions. For example, it is not uncommon to see cross sections with drips detailed on them where no provision has been made to cater for the resulting flow of water along the direction of the drip, at its termination.

C5.1.2 Drip details

Drips will inevitably slope in their longitudinal dimension and water may run, or be blown along them until it hits a surface that it can run down, such as a pier or abutment. If it can be sensitively accommodated, a vertical feature in the face of the pier or abutment may be employed to contain any potential streaking. Deck soffits often exhibit unsightly streaking from water driven onto girder webs.

Where edge cantilevers and properly detailed drip features are incorporated, the deck can generally be protected from water running from above.

If a fascia incorporates joints (as is common with precast elements) water may eventually penetrate the joint and bypass the drip. A secondary drip in the soffit of the slab behind the fascia can protect the main structure, not only from water which gets through the joint in the fascia, but also from water flowing over the edge of the deck before the fascia is constructed that may carry particles of rust or other debris from construction related materials and activities on the deck.

C5.1.3 Vertical faces

Elements with vertical faces such as fascia panels, piers and abutments are most vulnerable, particularly in urban environments. Careful detailing incorporating special finishes can help to control and minimise the effects of staining or streaking.

A projection from a vertical surface will inhibit water from washing over the surface immediately below it. A projection of limited length will have a darker unwashed area beneath it, which is likely to contrast with the rest of the surface.

C5.1.4 Concrete surfaces

Smooth concrete surfaces often weather badly, regardless of the surface quality achieved. No matter how uniform the surface appears to be, water may flow down in irregular paths resulting in random streaks.

Textured surfaces perform markedly better, for example when tooled or cast against sawn board formwork. Some proprietary form liners may also produce surfaces which avoid streaking, but many will incorporate a pattern that repeats in consecutive panels, which itself may be visually inappropriate.

Surfaces with closely spaced vertical ribs or grooves can work effectively to channel the water so that it cannot spread out to cause streaks.

Finishes that are used to prevent water runs from streaking concrete surfaces may also be considered as opportunities to give texture to the surface.

C5.1.5 Use of trial panels

There is often considerable merit in including the requirement for the production of full-scale trial panels when structures incorporate highly visible concrete surfaces or features. These should be constructed on site by the contractor as far in advance of the works to which they relate as can be reasonably

accommodated within the programme in order to allow modifications to be made if necessary based on their outcomes.

The trial panel will serve numerous functions from testing of the designer's decisions in terms of colour, surface textures and weathering behaviour as well as of the contractor's ability to deliver the designer's intent. They can also provide invaluable insights in terms of verifying the proposed construction methods, the suitability of the reinforcement detailing, the formwork finishes and the suitability of the concrete mix itself.

CS 171 [Ref 5.I] provides guidance on concrete trial panels.

C5.1.6 Weathering steel

The use of weathering steel poses particular challenges and water that has been in contact with it should be carefully managed such that it does not come into contact with any adjacent concrete surfaces.

Guidance on detailing of weathering steel can be found in CD 361 [Ref 6.I].

C5.2 Joints

The location and detailing of expansion joints should be carefully considered in the design. Generally these should be avoided as far as is possible to circumvent any associated durability or weathering problems. Joints will inevitably leak during their service life and the structure should therefore be detailed such that any leakage can be contained or managed in a way that does not result in unsightly staining.

Leakage of joints is far more straightforward to manage at abutments than over piers or within a span.

C5.3 Parapets

Parapets serve several core functions, including:

1) safely containing people or vehicles or other objects;
2) giving a sense of security to users of the bridge;
3) providing a visual edge to the deck as seen from off the bridge;
4) allowing bridge users to experience the landscape.

Too often only the first of these is given any significant degree of attention, both during design and when preparing and interpreting standards.

High containment parapets are difficult to accommodate visually and should be carefully considered, especially where (as is often the case), they are not continuous over the full length of the bridge. Where the related element proportions allow, it may be feasible to express the continuity of the bridge fascia by means of a shadow line and possibly a change of texture.

A parapet that is at least partly of concrete can provide a thicker element as part of the edge of the deck. The parapet is the most brightly lit part of the deck as seen from off the bridge and varying the height of this element can be an important tool in influencing perceptions of the scale or proportion of the bridge.

The top surface of the parapet upstand should be detailed with an inward fall to avoid streaking to the outer face as a result of water runoff focused at post positions. CIRIA C543 [Ref 1.I] provides guidance on this.

C5.4 Drainage

All water run-off should be fully managed, collected and controlled via positive, well designed and detailed drainage system to avoid unsightly staining of visible surfaces and finishes or deterioration of materials. Particular attention should be paid to managing leakage through movement joints.

C5.4.1 Drainage pipes

Where drainage pipes are exposed, they should be treated as any other design element as part of the whole. Pipe runs should be routed to minimise their visual impact arising from their line, scale and rhythm in relation to other elements of the structure. In addition, the effect of material and colour of the pipes should be considered.

Where it is not possible to avoid positioning pipe runs below edge cantilevers, they may be shielded behind parapet downstands, as long as this does not compromise the overall aesthetic of the deck itself.

C5.5 Lighting columns and other deck furniture

C5.5.1 Lighting columns

Lighting columns on bridges are best avoided on short-span structures by placing them outside the abutments. Where lighting columns have to be accommodated along a structure then they should be considered as an integral part of the aesthetic design. Their rhythm in relation to span lengths, height of the lighting columns and the integration of any necessary fixing corbels within the overall detailing of the deck can be critical visual factors.

C5.5.2 Wind shielding

When wind shielding is being considered, a range of aspects should be studied and tested, including:

1) the aerodynamic effects on the structure and traffic;
2) the effects on the appearance of the bridge;
3) the impact on the view from vehicles crossing the bridge.

C5.5.3 Effects of bridge details and surrounding landscape

Graphical methods can be used to study the combined effect of the bridge details interposed between occupants of vehicles and the surrounding landscape, i.e. wind shields, safety fences and parapets, but are no substitute for experiencing the real thing. This is a case where computer generated imagery can be extremely useful, but with the same proviso.

C5.6 Light and shade

Bridges are forms seen in light and by means of light. Differences of light intensity reveal the outlines of elements and the appearance of a structure can be modified by shaping its form such that one part attracts light or gives shade to another.

In daylight, where reflected light is usually of low intensity, the amount of light on a surface is dictated by its orientation and attitude relative to the sky.

Vertical surfaces will be better lit than soffits, and a sloping soffit which can be seen in elevation will appear darker than a vertical face. This is partly why a trapezoidal box deck with fairly shallow side slopes appears more recessive than a rectangular box of similar depth.

Where a bridge deck incorporates an edge cantilever, the most intensely lit element will be the face of the cantilever, which by its nature casts shadows on the surfaces beneath it.

Small projections from a vertical surface reveal their presence by shadows in the same way that the mouldings on a classical building are read. Vertical edges on projections can also reveal themselves in this way, depending on the direction from which the highest intensity light is coming. Surface textures such as vertical ribbing depend on this for their effect. A ribbed surface appears markedly different from a plain surface at a distance, even though it is not possible to distinguish individual ribs.

When a bridge crosses water, the underside can be lightened by reflection from the water. Sunlight reflected from waves or ripples can often produce a desirable visual outcome.

'Architectural' or 'feature lighting of bridges', where appropriate, should be considered in the whole and emphasise the basic geometric form of the structure. It can be particularly effective on structures that cross bodies of water. It should be integrated with any requirements for street lighting and ideally the

luminaires should be energy efficient, not result in light spill and be easily maintained. A mixture of colours of light can help emphasise the various elements of the structure but care should be taken to avoid distorting the visual balance of the structure.

C5.7 Colour and tone

Colour and tone influence our perception of aesthetics. They can be used to enhance definition, clarity and to accentuate or subdue the visual impact of elements. Their selection should always be given careful consideration within the predominant context of the bridge site.

For example, a light toned concrete bridge will stand out clearly against a background of dark foliage whereas a steel bridge painted in a darker tone would be less conspicuous. Light grey makes fine elements like balustrades less noticeable against a grey sky whereas using a dark tone for lamp posts may make them blend within a background of dark foliage. It should however be borne in mind of course that the sky is not always grey and many types of foliage changes with the seasons. A dark beam, whether achieved through painting or shadow, appears further recessed against a light edge cantilever than would a light one.

Colour schemes for painting trusses should emphasise the structural form and make a clear distinction between structure and ancillary items such as balustrades, handrails, lighting columns, infill panels, etc.

C6 Bridge specific challenges

C6.1 New structures sited adjacent to existing structures

When a new bridge is to be placed next to an existing one, it should respect the presence of the existing structure, the landscape and visual impact of the site. If possible, the new bridge should be located so that the two bridges are seen as separate elements in the landscape and can be designed as separate entities, for example, the various bridges over the River Tyne.

Ideally there should be space between the two bridges allowing sufficient separation for each structure to be viewed from the other. This can be achieved through collaboration with the highway engineers when developing the alignment design.

It is usually more appropriate to place an openly contemporary bridge beside an existing one. The proportions and rhythm of the existing structure should be respected as far as is possible; this does not mean that every pier of the older bridge should have a corresponding new one but the rhythm of the piers should be complementary. When siting a new bridge adjacent to an existing arched structure, the new structure should avoid cutting across the profile of the arch opening(s).

C6.2 Bridge widening

In general, it is difficult to widen an existing bridge in a way which is aesthetically acceptable, unless the option for future widening has been specifically considered during its original design. The widening of existing structures introduces risks and complications to both the design and construction phases.

Where site constraints mean that bridge widening is unavoidable, then it is important that the character of the existing structure is respected and maintained. This will usually mean maintaining the original materials and character as closely as possible but in some circumstances, a light and transparent addition to a structure of significant mass may be successful if sensitively detailed.

When widening an existing structure that is listed or of historic significance (e.g. scheduled ancient monument) this should be reflected in the AC allocated.

Wherever it is possible and it can be demonstrated to be reasonably cost effective, it is preferable to develop a highway design that will accommodate a second bridge or a complete replacement. Where the primary need is to provide additional space for walking, cycling and horse-riding users in accordance with GG 142 [Ref 5.N] then the provision of a new pedestrian bridge can often avoid the need for the invasive widening of an historic bridge.

C6.3 Alignment

It is important that there is close collaboration at the earliest stages of design between the highway and bridge designers with the aim of avoiding the need to accommodate slip lanes that result in plan tapers, excessive skew angles, high degrees of super-elevation or the need to accommodate pedestrian steps and ramps. All of these constraints will add visual clutter that may compromise aesthetics and complicate both the design and construction of the bridge.

C6.4 New materials

When new materials or construction methods are introduced, there is often a transition period during which structural forms and details emerge that are appropriate aesthetically as well as technically.

The use of new materials should be implemented rationally by experienced designers, with due regard for their individual properties, in order that they are honestly expressed within the form and detailing of the structure and appropriate to its function.

C6.5 Bridge enclosures

Where enclosures manufactured from GRP or other materials are provided to structural elements of bridges for durability or aesthetic purposes, they should be clearly shown as cladding elements, i.e. non-structural elements. Retrofitting of enclosure elements should be avoided.

C6.6 Decks curved in plan

Where horizontal alignment constraints results in a bridge deck to be curved in plan, the use of straight or faceted girders (comprising a series of short straight elements) should be avoided in preference for curved girders, unless the radius of curvature is so great that changes of line between successive spans are extremely small.

C6.7 Steel plate girder decks

Careful attention should be given to the detailing and visual impact of any splices, permanent bracing, exposed services or walkways on bridge decks which feature exposed plate girders.

Appendix D. Model AAD

A model AAD is shown in Table D.1

Table D.1 Model AAD

Initiation stage	
Structure name/reference	
Project Sponsor	
Aesthetic category and justification	
Structure location	
Function	
Site specific constraints and sensitivities	
Review panel requirements	
Design stage	
Design organisation	
Design team leader	
Changes to initiation stage information (aesthetic category etc.) and justification	
Key functional requirements	
Stakeholder consultation proposals	
Site context	
Design outcome objectives	
AAD update milestones	
Construction stage	
Changes to design stage information (e.g. as a result of value engineering proposals,site constraints or construction process requirements etc.)	
Post construction review	
Project Sponsor feedback	

Highway Structures & Bridges
Design

CD 351
England National Application Annex to CD 351
The design and appearance of highway structures

(formerly BA 41/98)

Revision 0

Summary
This National Application Annex sets out the Highways England-specific requirements for the design and appearance of highway structures.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
0	Mar 2020	Highways England National Application Annex to CD 351.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes part of BA 41/98, which is withdrawn.

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

Background

This National Application Annex sets out Highways England's specific requirements for the design and appearance of highway structures, and the relation to the principles of good road design as set out in the Road to Good Design [Ref 3.I] publication by Highways England.

Highway structures, and bridges in particular, are some of the largest and most visible man-made objects. Their appearance and how they sit within the landscape is therefore an important aspect of the design.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 1.I] apply to this document.

Abbreviations

Abbreviations

Abbreviation	Definition
AAD	Aesthetic Appraisal Document
PCF	Project Control Framework
PRP	Project Review Panel (as established within CD 351 [Ref 2.I])
SDP	Strategic Design Panel
SRO	Senior Responsible Owner

Terms and definitions

Terms

Term	Definition
Design life-cycle	The period of time between the inception of design and the point at which the designed item no longer exists in its designed form. NOTE: Design life-cycle includes the stages of option identification, option selection, preliminary design and detailed design and is to include any design changes that occur during the construction and commissioning period.
Project Review Panel	A body which includes representation from the stakeholders in the project (e.g. from the Overseeing Organisation or users of the project deliverables), which helps ensure that the principles of good road design have been taken into account for an individual road scheme / project or a specific programme.
Senior Responsible Owner	The individual responsible for ensuring that a programme or project meets its objectives and delivers the projected benefits.
Strategic Design Panel	The independent panel supporting Highways England to make a step change in the design quality of the strategic as described in the Road to Good Design [Ref 3.I] publication by Highways England.

E/1. Aesthetic appraisal document (CD 351, 3)

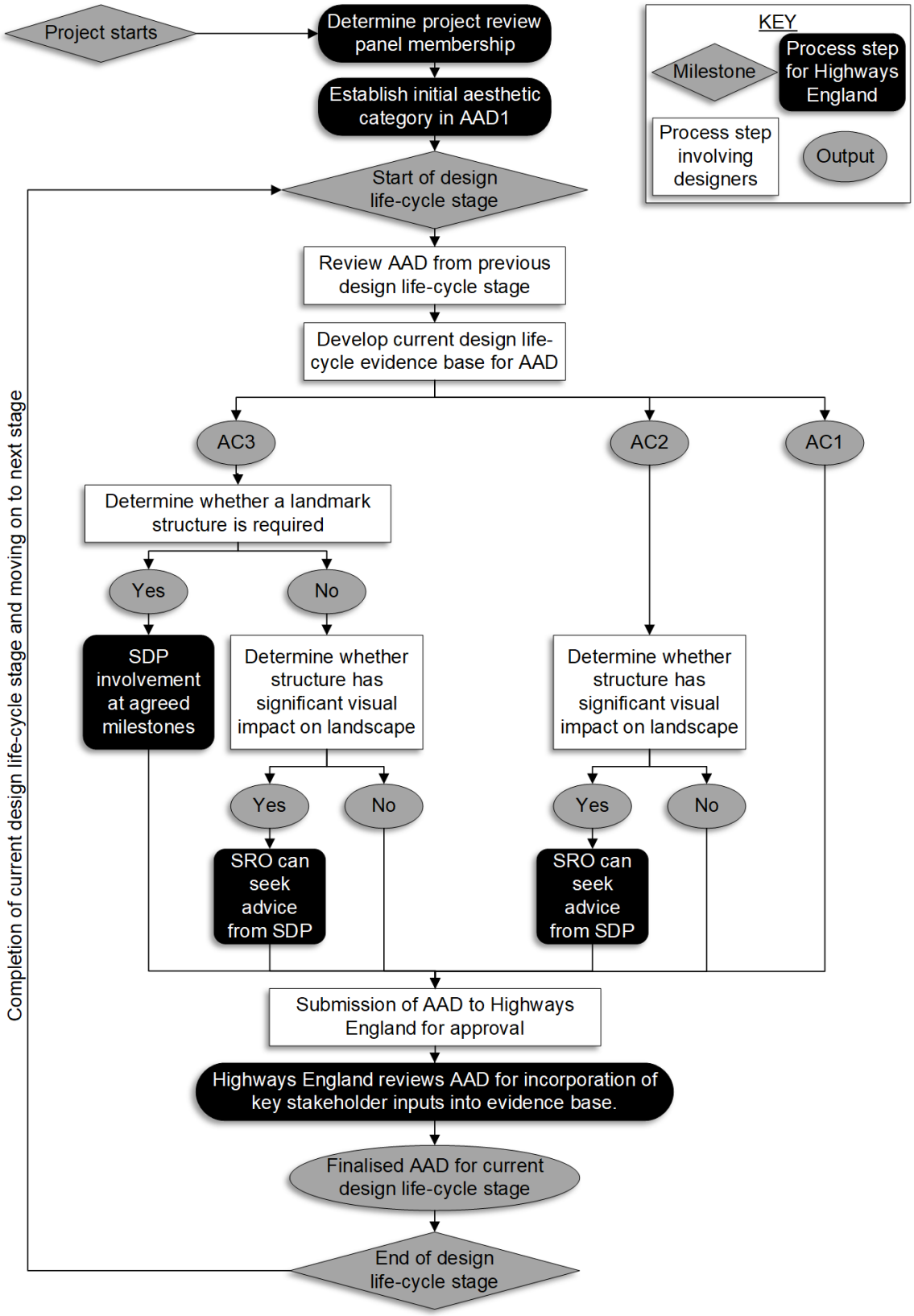
Demonstrating compliance with the principles of good road design

E/1.1 The aesthetic appraisal document (AAD) shall be developed and updated throughout the design life-cycle to demonstrate compliance with the principles of good road design.

NOTE 1 The principles of good road design are described in the Road to Good Design [Ref 3.I] publication by Highways England.

NOTE 2 The aesthetic evaluation process within the design life-cycle is shown in Figure E/1.1N2:

Figure E/1.1N2 Aesthetic evaluation process within the design life-cycle



NOTE 3 The Strategic Design Panel (SDP) is described in the Road to Good Design [Ref 3.I] publication by Highways England.

NOTE 4 For major projects, the design life-cycle stages of the AAD correspond to the PCF stages as shown in Table E/1.1N4:

Table E/1.1N4 AAD design life-cycle stage mapped to PCF stages

Design life-cycle stage	PCF stage
AAD1(1) - project initiation (prior to option finalisation)	PCF stage 2 - option selection
AAD2.1 - preliminary design	PCF stage 3 - preliminary design
AAD2.2 - detailed design	PCF stage 5 - construction preparation
AAD3 - construction	PCF stage 6 - construction
AAD4 - post construction review	PCF stage 7 - closeout
Note (1): AAD1 is developed by Highways England and typically forms part of the project brief. Subsequent versions of the AAD are outputs from the aesthetic evaluation process during the design life-cycle.	

Developing the AAD

E/1.2 The outcomes of actions that result from Highways England reviews shall be recorded in the AAD.

E/1.3 On completion of each stage of the design life-cycle, the AAD shall be submitted to Highways England for approval as part of the stage gate assessment review process.

E/2. Informative references

The following documents are informative references for this document and provide supporting information.

Ref 1.I	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 2.I	Highways England. CD 351, 'The design and appearance of highway structures'
Ref 3.I	Highways England. Road to Good Design, 'The Road to Good Design'

Department for Infrastructure
An Roinn Bonneagair

Highway Structures & Bridges
Design

CD 351
Northern Ireland National Application Annex to CD 351 The design and appearance of highway structures

(formerly BA 41/98)

Revision 0

Summary
There are no specific requirements for Department for Infrastructure, Northern Ireland supplementary or alternative to those given in CD 351.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated team in the Department for Infrastructure, Northern Ireland. The email address for all enquiries and feedback is: dcu@infrastructure-ni.gov.uk

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Design

CD 351
Scotland National Application Annex to CD 351 The design and appearance of highway structures

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Summary
There are no specific requirements for Transport Scotland supplementary or alternative to those given in CD 351.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Transport Scotland team. The email address for all enquiries and feedback is: TSStandardsBranch@transport.gov.scot

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Llywodraeth Cymru
Welsh Government

Highway Structures & Bridges
Design

CD 351
Wales National Application Annex to CD 351
The design and appearance of highway structures

(formerly BA 41/98)

Revision 0

Summary
There are no specific requirements for Welsh Government supplementary or alternative to those given in CD 351.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Welsh Government team. The email address for all enquiries and feedback is: Standards_Feedback_and_Enquiries@gov.wales

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